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CONCERNING MAN'S ORIGIN

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A FOREWORD

IN Chapters I, II, and III of this small book is reproduced my Presidential Address on "Darwin's Theory of Man's Origin as it Stands To-day," given to the British Association when it met in Leeds on August 31, 1927. I have added a few footnotes and amplified certain passages, but otherwise the original text stands unchanged. In Chapter IV I have touched upon certain interesting matters concerning man's origin which could not be compressed into an address of an hour's duration, but with which I had dealt in a lecture given in memory of Huxley. Much of Chapter IV is taken from that lecture. Chapter V reproduces an essay on Darwin's home at Down, contributed to the *Rationalist Press Association Annual* for 1923. Chapter VI was published in the same publication for 1922, and gives reasons for my allegiance to Darwin. "Capital as a Factor in Evolution," also contributed to the *R.P.A. Annual*, is reproduced as a final chapter because it has an important bearing on man's evolution. Accumulated wealth and accumulated knowledge have made our modern civilization possible. Similar factors have been at work in the evolution of the Higher Primates, and made possible the appearance of man amongst them.

I am indebted to the enterprise of Messrs. Watts & Co. for the issue of my address and cognate essays in this cheap and accessible form. My address, almost the shortest in the record of the British Association, cost me considerable pains, but its brevity was not due to a lack of material. For round me, as I wrote, were the accumulations of forty years spent on investigating the human body, and in comparing its structure and function with those of animals which stand near man in the zoological scale. I have made it a habit to assimilate, as I go along, the hundreds of researches of a kind similar to my own which are issued every year from laboratories at home and abroad. I had made this huge accumulation of data, not with any thought that it might have a bearing on beliefs which men and women cherish, but merely with a view

of satisfying the needs of medical students. No teacher can give a reasonable explanation of the human body to his students unless he accepts the historical background which Darwin has supplied for man's past. I framed my Presidential statement to embrace the broad outlines which are accepted as true amongst men who have to understand the human body and treat its ailments on a basis of rational knowledge. I prided myself not on what I had succeeded in compressing into it, but on the resolution I exercised in sacrificing so much that was relevant to my argument.

I knew that the matter of my address would give rise to no perturbation in the minds of men who were working at other branches of science. The botanist and zoologist cannot breathe or move at his work unless you permit him to be an evolutionist. The work-a-day life of the geologist is spent in deciphering the past history of the earth's crust and all that has lived and moved upon it in past times. Those who are dissecting the structure of atoms are finding that even the elements are and have ever been in a process of evolution. The astronomer finds history in the heavens; every star is in a process of change. Nothing is still; all is moving and unfolding, particularly man's own world—his world of belief, thought, and action. Man's way of living and of thinking has never remained stationary; workers in every branch of knowledge find ample evidence of the truth of evolution. To such men I feared that my address would appear but a tame statement of accepted fact.

As I gave my address I could evoke no response from the sea of faces in front of me—only a stolid attention; and the feeling grew within me that I was committing the most heinous sin possible from a platform—boring my audience. My worst fears were being realised—that the dish I was serving up was proving to be stale and insipid. So I cut my address short, although it pained me to jettison what I regarded as its newest and most crucial paragraphs—here reproduced in full.

On the morning following my address I began to be undeceived, and to realise that we who work in laboratories and move in the secluded circles of scientific London do not know what England is thinking. To learn that one has apparently to go to the provinces—particularly to the North, where men and women are earnest in thought and vigorous in their work and play. I learned from the outburst in the public press that Daytonism is very much alive throughout the land, and that

the only science many people are prepared to accept is that enshrined in the book of Genesis, which, as all Biblical scholars admit, represents the state of ignorance which prevailed in Eastern lands during the millennium that immediately preceded the Christian Era. For such men and women all modern science is rank heresy; they would gladly scrap Darwin and all his works. That is one way of solving a troublesome problem, but it is not one which commends itself to rational men and women.

Even more hostile than the Daytonians is the strenuous opposition led by a group of men who may be regarded as Daytonian Darwinists. They believe, as followers of Charles Darwin do, that man has been evolved from a lower form; they are indifferent as to the kind of animal selected as an ancestor. They hold the belief that when man's evolution had proceeded some way a miracle occurred, and something that no ape ever had was suddenly grafted in the evolving human brain. To illustrate this point of view, let me quote from an article written by a learned critic in the "Christian World." In criticising my address he wrote: "The opening and somewhat jubilant review of the mid-Victorian battle between science and religion raised one's hopes, but he passed on to show proof once more for the common ancestry, in far-off ages, of man and the anthropoid apes. The point is, of course, now scarcely worth debating." I was rather taken aback when my critic, who had gone thus far with me, turned upon me and rent me because I repeated the old fact that we whose business it is to search out such things had found that "the human brain reveals no formation of any sort which is not present in the brain of the gorilla and chimpanzee." All the evidence at our disposal supports the conclusion that the biological factors which raised the anthropoid brain from that of a lower ape were also those which ultimately transformed an anthropoid brain into man's master-organ. In my address I had to confess that we do not know as yet what these brain-expanding factors are. To ascribe them to a miraculous intervention is one way of solving the problem, but it is not one which will be accepted by men who have resolved to find out the kind of universe we live in and the kind of being man is by the resolute prosecution of scientific enquiry.

I have summed up thus briefly the objections which have been lodged against my statement of the Darwinian position. It is here, too, that I must place on record that the impression

I formed of the attitude of my audience to my address was a mistaken one. My fellow workers, for whom I stood but as spokesman, have commended the moderation of my statements, and hold that I acted wisely in eliminating from my discourse the many debatable problems which still confront those who are seeking to unravel man's long pedigree. More especially have I been encouraged by the reception given by the leaders of religious thought. Far from being in opposition, they want to know all that can be known of the universe in which we live, and of that remarkable aberrant product of Nature which we call Man. They have grown up in the post-Darwinian period, and no longer regard the great army of science as an enemy, but as a friendly power. They realise that religion cannot stand still, that it too must evolve, and that it is the duty of theologians not to expect scientific men to modify their facts to fit religious views, but that religion must be modified to fit man's changing needs, and to be in keeping with the truth as revealed by scientific enquiry. It may take long before we reach perfect accord, but nothing but good can come out of a working agreement effected between men who are striving for the betterment of humanity through an increase of well-ascertained knowledge. Religious leaders and men of science have the same ideals; they want to understand and explain the universe of which they are part; they both earnestly desire to solve, if a solution be ever possible, that great riddle: Why are we here?

CONTENTS

CHAPTER I

How Our Modern Conception of Man's Origin has Come About

[The text of this address has been kept in the form in which it was delivered. It was given at the inaugural meeting of the British Association held in Leeds on August 31, 1927. The author had then the honour of succeeding H.R.H. The Prince of Wales as President of the Association. The meeting held in Oxford in 1926, when the Prince of Wales became President, was the most successful in the history of the Association.]

IN olden times men kept their calendars by naming each year according to its outstanding event. I have no doubt that in future times the historian of this Association, when he comes to distinguish the Presidential year which opened so auspiciously in Oxford twelve months ago, will be moved to revert to this ancient custom and name it the PRINCE'S YEAR. And I am under no misapprehension as to what will happen when our historian comes to the term which I have now the honour of inaugurating at Leeds; he will immediately relapse to the normal system of numerical notation. Nor will our historian fail to note, should he be moved to contrast the meeting at Oxford with that which now begins at Leeds, that some mischievous sprite seems to have tampered with the affairs of this Association. For how otherwise could he explain the fortune which fell to ancient Oxford, the home of history? To her lot fell a brilliant discourse on the application of science to the betterment of human lives, while Leeds, a city whose life's blood depends on the successful application of science to industry, had to endure, as best she could, a discourse on a theme of ancient history. For the subject of this address is man's remote history. Fifty-five years have come and gone since Charles Darwin wrote a history of man's descent. How does his work stand the test of time? This is the question I propose to discuss in the brief hour at my disposal.

The Opening Shot in the Darwinian Battle

In tracing the course of events which led up to our present conception of man's origin, no place could serve as a historical starting-point so well as Leeds. In that city was fired the first verbal shot of the long and bitter strife which ended in the overthrow of those who defended the Biblical account of man's creation and in a victory for Darwin. On September 24, 1858—sixty-nine years ago—the British Association assembled in this city just as we do to-night; Sir Richard Owen,[1] the first anatomist of his age, stood where I now stand. He had prepared a long address, four times the length of the one I propose to read, and surveyed, as he was well qualified to do, the whole realm of science; but only those parts which concern man's origin require our attention now. He cited evidence which suggested a much earlier date for the appearance of man on earth than was sanctioned by Biblical records, but poured scorn on the idea that man was merely a transmuted ape. He declared to the assembled Association that the differences between man and ape were so great that it was necessary, in his opinion, to assign mankind to an altogether separate Order in the animal kingdom. As this statement fell from the President's lips there was at least one man in the audience whose spirit of opposition was roused—Thomas Henry Huxley—Owen's young and rising antagonist.

Owen and Huxley

I have picked out Huxley from Owen's audience because it is necessary, for the development of my theme, that we should give him our attention for a moment. We know what Huxley's feelings were towards Owen at the date of the Leeds meeting. Six months before, he had told his sister that "an internecine feud rages between Owen and myself," and on the eve of his departure for Leeds he wrote to Hooker: "The interesting question arises: shall I have a row with the great O. there?" I am glad to say the Leeds meeting passed off amicably, but it settled in Huxley's mind what the 'row' was to be about when it came. It was to concern Man's rightful position in the scale of living things.

[1] At this time Sir Richard Owen considered himself as very 'advanced,' and was regarded with suspicion by orthodox Churchmen. He is one of the greatest anatomists produced by England.

Man's Position in the Animal Kingdom

Two years later, in 1860, when this Association met in Oxford, Owen gave Huxley the opportunity he desired. In the course of a discussion Owen repeated the statement made at Leeds as to man's separate position, claiming that the human brain had certain structural features never seen in the brain of anthropoid apes. Huxley's reply was a brief and emphatic denial with a promise to produce evidence in due course—which was faithfully kept. This opening passage at arms between our protagonists was followed two days later by that spectacular fight—the most memorable in the history of our Association—in which the Bishop of Oxford, the representative of Owen and of orthodoxy, left his scalp in Huxley's hands. To make his victory decisive and abiding, Huxley published, early in 1863, "The Evidences of Man's Place in Nature," a book which has a very direct bearing on the subject of my discourse. It settled for all time that man's rightful position is among the Primates, and that, as we anatomists weigh evidence, his nearest living kin are the anthropoid apes.

Owen's Opinion of Darwinism

My aim is to make clear to you the foundations on which rest our present-day conception of man's origin. The address delivered by my predecessor from this chair at the Leeds meeting of 1858 has given me the opportunity of placing Huxley's fundamental conception of man's nature in a historical setting. I must now turn to another issue which Sir Richard Owen merely touched upon, but which is of supreme interest to us now. He spent the summer in London, just as I have done, writing his address for Leeds and keeping an eye on what was happening at scientific meetings. In his case something really interesting happened.[1] Sir Charles Lyell, the leading geologist of his time, and Sir Joseph Hooker, the great botanist, left with the Linnean Society in London what appeared to be an ordinary roll of manuscript, but which in reality was a parcel charged with high explosives, prepared by two very innocent-looking men—Alfred Russel Wallace and Charles Darwin. As a matter of honesty it must be

[1] It is possible that an equally interesting discovery has been announced in the summer of 1927, and that I have failed to perceive its importance.

admitted that these two men were well aware of the deadly nature of its contents, and knew that, if an explosion occurred, man himself, the crown of creation, could not escape its destructive effects. Owen examined the contents of the parcel and came to the conclusion that they were not dangerous; at least, he manifested no sign of alarm in his Presidential Address. He dismissed both Wallace and Darwin, particularly Darwin, in the briefest of paragraphs, at the same time citing passages from his own work to prove that the conception of natural selection as an evolutionary force was one which he had already recognised.

The Transformation of our Outlook on Man's Origin

As I address these words to you I cannot help marvelling over the difference between our outlook to-day and that of the audience which Sir Richard Owen had to face in this city sixty-nine years ago. The vast assemblage which confronted him was convinced, almost without a dissentient, that man had appeared on earth by a special act of creation; whereas the audience which I have now the honour of addressing, and that larger congregation which the wonders of wireless bring within the reach of my voice, if not convinced Darwinists are yet prepared to believe, when full proofs are forthcoming, that man began his career as a humble primate animal, and has reached his present estate by the action and reaction of biological forces which have been and are ever at work within his body and brain.[1]

Darwin's Generalship

This transformation of outlook on man's origin is one of the marvels of the nineteenth century, and to see how it was effected we must turn our attention for a little while to the village of Down in the Kentish uplands and note what Charles Darwin was doing on the very day that Sir Richard Owen was delivering his address here in Leeds.[2] He sat in his study struggling with the first chapter of a new book; but

[1] In this, as stated in my Foreword, I was soon to be undeceived, for on the publication of this address a storm of criticism and of opposition instantly arose in the public press—almost as vigorous in its outcry as in Darwin's time.

[2] For an account of Darwin's home at Down see Chapter V.

no one foresaw, Owen least of all, that the publication of the completed book, "The Origin of Species," fifteen months later (1859), was to effect such a sweeping revolution in our way of looking at living things and to initiate a new period in human thought—the Darwinian period—in which we still are. Without knowing it, Darwin was a consummate general. He did not launch his first campaign until he had spent twenty-two years in stocking his arsenal with ample stores of tested and assorted fact. Having won territory with "The Origin of Species," he immediately set to work to consolidate his gains by the publication in 1868 of another book, "The Variation of Animals and Plants under Domestication"—a great and valuable treasury of biological observation. Having thus succeeded in establishing an advanced base, he moved forwards on his final objective—the problem of Human beginnings—by the publication of "The Descent of Man" (1871), and that citadel, in time, capitulated to him. To make victory doubly certain he issued in the following year—1872—"The Expression of the Emotions in Man and Animals." Many a soldier of truth had attempted to capture this citadel before Darwin's day, but they failed because they had neither his generalship nor his artillery.

History as Written by Darwin

Will Darwin's victory endure for all time? Before attempting to answer this question, let us look at what kind of book "The Descent of Man" is. It is a book of history—the history of man, written in a new way—the way discovered by Charles Darwin. Permit me to illustrate the Darwinian way of writing history. If a history of the modern bicycle had to be written in the orthodox way, then we should search dated records until every stage was found which linked the two-wheeled hobby-horse, bestrode by tall-hatted fashionable men at the beginning of the nineteenth century, to the modern 'jeopardy' which now flashes past us in country lanes. But suppose there were no dated records—only a jumble of antiquated machines stored in the cellar of a museum. We should, in this case, have to adopt Darwin's way of writing history. By an exact and systematic comparison of one machine with another we could infer the relationship of one to another and tell the order of their appearance, but as to the date at which each type appeared, and the length of time

it remained in fashion, we could say very little. It was by adopting this circumstantial method that Darwin succeeded in writing the history of man. He gathered historical documents from the body and behaviour of man and compared them with observations made on the body and behaviour of every animal which showed the least resemblance to man. He studied all that was known in his day of man's embryological history and noted resemblances and differences in the corresponding histories of other animals. He took into consideration the manner in which the living tissues of man react to disease, to drugs, and to environment; he had to account for the existence of diverse races of mankind. By a logical analysis of his facts Darwin reconstructed and wrote a history of man.[1]

[1] By the same method detectives often succeed in reconstructing the history of unseen crimes. Men are sentenced to death on the strength of circumstantial evidence. The creation of the world cannot in any sense be regarded as a crime, yet those who are unravelling its secrets do use the methods of the criminal detective. In this sense Darwin was the greatest criminal detective the world has yet seen.

CHAPTER II

Advances in Our Knowledge Made since Darwin's Time

DARWIN'S POSITION HAS BECOME IMPREGNABLE

FIFTY-SIX years have come and gone since Darwin wrote his account of man's origin; during that period an enormous body of new evidence has poured in upon us. We are now able to fill in many pages which Darwin had perforce to leave blank, and we have found it necessary to alter details in his narrative; but the fundamentals of Darwin's outline of man's history remain unshaken. Nay, so strong has his position become that I am convinced that it never can be shaken.

THE EVIDENCE OF FOSSIL REMAINS

Why do I say so confidently that Darwin's position has become impregnable? It is because of what has happened since his death in 1882. Since then we have succeeded in tracing man by means of his fossil remains and by his stone implements backwards in time to the very beginning of that period of the earth's history which preceded the Present, and to which the name Pleistocene is given. We thus reach a point in history which is distant from us at least 200,000 years, perhaps three or four times that amount, for as yet we have no exact means of estimating the duration of geological periods in terms of years. Nay, we have gone farther, and traced him into the older and longer period which preceded the Pleistocene—the Pliocene. It was in strata laid down by a stream in Java during the latter part of the Pliocene period that Dr. Eugene Dubois found, ten years after Darwin's death, the fossil remains of that remarkable representative of primitive humanity to which he gave the name Pithecanthropus, or ape-man; from Pliocene deposits of East Anglia Mr. Reid Moir has recovered rude stone implements, thus providing reliable evidence of the existence of a form of humanity in England at this remote date.

If Darwin was right, then as we trace man backwards in the scale of time he should become more bestial in form—nearer to the ape. That is what we have found. But if we regard Pithecanthropus with his small and simple yet human brain as a fair representative of the men of the Pliocene period, then evolution must have proceeded at an unexpectedly rapid rate to culminate to-day in the higher races of mankind.

Man's Descent has not been in a Straight Line

The evidence of man's evolution from an ape-like being, obtained from a study of fossil remains, is definite and irrefutable, but the process has been infinitely more complex than was suspected in Darwin's time. Our older and discarded conception of man's transformation was depicted in that well-known diagram which showed a single file of skeletons, the gibbon at one end and man at the other. In our original simplicity we expected, as we traced man backwards in time, that we should encounter a graded series of fossil forms—a series which would carry him in a straight line towards an anthropoid ancestor. We should never have made this initial mistake if we had remembered that the guide to the world of the past is the world of the present. In our time man is represented not by a single type but by many and diverse races—black, brown, yellow, and white; some of these are rapidly expanding, others are as rapidly disappearing. Our searches have shown that in remote times the world was peopled, sparsely it is true, with races showing even a greater diversity than those of to-day, and that already the same process of replacement was at work. To unravel man's pedigree, we have to thread our way, not along the links of a chain, but through the meshes of a complicated network.

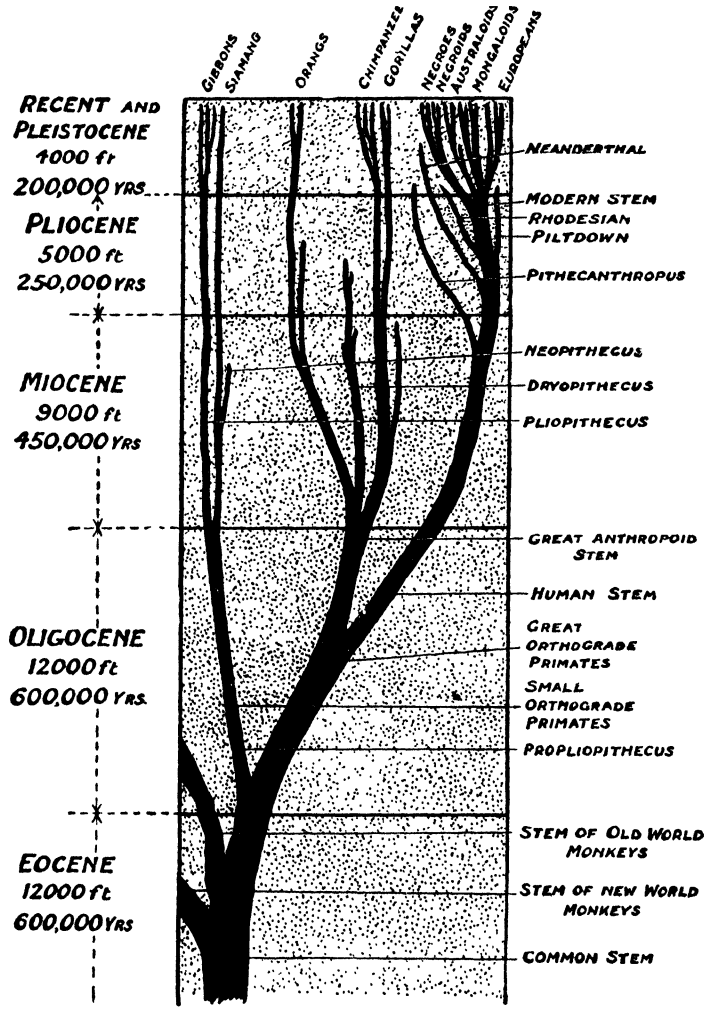
The Diversity of Form in Ancient Times

We made another mistake. Seeing that in our search for man's ancestry we expected to reach an age when the beings we should have to deal with would be simian rather than human, we ought to have marked the conditions which prevail amongst living anthropoid apes. We ought to have been prepared to find, as we approached a distant point in the geological horizon, that the forms encountered would be as widely different as are the gorilla, chimpanzee, and orang, and confined, as these great anthropoids now are, to limited

parts of the earth's surface. That is what we are now realising; as we go backwards in time we discover that mankind becomes broken up, not into separate races as in the world of to-day, but into numerous and separate species. When we go into a still more remote past they become so unlike that we have to regard them not as belonging to separate species, but as different genera. It is amongst this welter of extinct fossil forms which strew the ancient world that we have to trace the zigzag line of man's descent. Do you wonder we sometimes falter and follow false clues?

Discordant Evolution

We committed a still further blunder when we set out on the search for man's ancestry; indeed, some of us are still making it. We expected that man's evolution would pursue not only an orderly file of stages, but that every part of his body—skull, brain, jaws, teeth, skin, body, arms, and legs—would at each stage become a little less ape-like, a little more man-like. Our searches have shown us that man's evolution has not proceeded in this orderly manner. In some extinct races, while one part of the body has moved forwards another part has lagged behind. Let me illustrate this point, because it is important. We now know that, as Darwin sat in his study at Down, there lay hidden at Piltdown, in Sussex, not thirty miles distant from him, sealed up in a bed of gravel, a fossil human skull and jaw. In 1912, thirty years after Darwin's death, Mr. Charles Dawson discovered this skull and my friend Sir Arthur Smith Woodward described it, and rightly recognised that skull and jaw were parts of the same individual, and that this individual had lived, as was determined by geological and other evidence, in the opening phase of the Pleistocene period. We may confidently presume that this individual was representative of the people who inhabited England at this remote date. The skull, although deeply mineralised and thick-walled, might well have been the rude forerunner of a modern skull, but the lower jaw was so ape-like that some experts denied that it went with the human fossil skull at all, and supposed it to be the lower jaw of some extinct kind of chimpanzee. This mistake would never have been made if those concerned had studied the comparative anatomy of anthropoid apes. Such a study would have prepared them to meet with the discordances of evolution. The



A Diagram to illustrate the author's conception of man's origin. The stippled background represents deposits formed during the later periods of the earth's history, while the black branching lines depict the family tree of the Higher Primates. In this diagram, adapted from *The Antiquity of Man*, the human stem is represented as separating from that of the great anthropoids towards the end of the Oligocene period.

same irregularity in the progression of parts is evident in the anatomy of Pithecanthropus, the oldest and most primitive form of humanity so far discovered. The thigh-bone might easily be that of modern man, the skull-cap that of an ape; but the brain within that cap, as we now know, had passed well beyond an anthropoid status. If merely a lower jaw had been found at Piltdown, an ancient Englishman would have been wrongly labelled 'Higher anthropoid ape'; if only the thigh-bone of Pithecanthropus had come to light in Java, then an ancient Javanese, almost deserving the title of anthropoid, would have passed muster as a man. It will be thus seen that the problem of unravelling man's evolutionary history is more complex than at first suspected.

Blanks still Remain in the Geological Record

Such examples illustrate the difficulties and dangers which beset the task of unravelling man's ancestry. There are other difficulties; there still remain great blanks in the geological record of man's evolution. As our search proceeds these blanks will be filled in, but in the meantime let us note their nature and their extent. By the discovery of fossil remains we have followed man backwards not only through the Pleistocene period, but also into the closing phase of the Pliocene—a period which endured at least for a quarter of a million years; but we have not yet succeeded in tracing him through this period. It is true that we have found fossil teeth in Pliocene deposits which may be those of an ape-like man or of a man-like ape; until we find other parts of their bodies we cannot decide. When we pass into the still older Miocene period—one which was certainly twice as long as the Pliocene—we are in the heyday of anthropoid history. Thanks to the labours of Dr. Guy E. Pilgrim, of the Indian Geological Survey, we know already a dozen different kinds of great anthropoids which lived in Himalayan jungles during middle and later Miocene times; we know of at least three other kinds of great anthropoids which lived in the contemporary jungles of Europe. Unfortunately we have found as yet only the most resistant parts of their bodies—teeth and fragments of jaw. Do some of these fragments represent a human ancestor? We cannot decide until a lucky chance brings to light a limb-bone or a piece of skull; but no one can compare the teeth of these Miocene anthropoids with those of primitive man, as

has been done so thoroughly by Prof. William K. Gregory, and escape the conviction that in the dentitions of the extinct anthropoids of the Miocene jungles we have the ancestral forms of human teeth.

Date of Man's Emergence

It is useless to go to strata still older than the Miocene in search of man's emergence; in such strata we have found only fossil traces of emerging anthropoids. All the evidence now at our disposal supports the conclusion that man has arisen, as Lamarck and Darwin suspected, from an anthropoid ape not higher in the zoological scale than a chimpanzee, and that the date at which human and anthropoid lines of descent began to diverge lies near the beginning of the Miocene period. On our modest scale of reckoning, that gives man the respectable antiquity of about one million years.

Proofs of our Anthropoid Ancestry

Our geological search, which I have summarised all too briefly, has not produced so far the final and conclusive evidence of man's anthropoid origin; we have not found as yet the human *imago* emerging from its anthropoid encasement. Why, then, do the majority of modern anthropologists share the conviction that there has been an anthropoid stage in our ancestry?[1] They are no more blind than you are to the degree of difference which separates man and ape in structure, in appearance, and in behaviour. I must touch on the sources of this conviction only in a passing manner. Early in the present century Prof. G. H. F. Nuttall, of the University of Cambridge, discovered a trustworthy and exact method of determining the affinity of one species of animal to another by comparing the reactions of their blood. He

[1] In Chapter IV the reader will find that there are exceptions. Dr. H. Fairfield Osborn and Professor F. Wood Jones, both men of brilliant capacity, believe that man broke away from the simian stem at a pre-anthropoid stage. Darwin, too, flirted with this idea. The reason for the author's agreement with the prevailing opinion that man has sprung from an anthropoid ancestor rests largely on a prolonged investigation into the modifications of man's body which are necessary for his posture and manner of walking. It is impossible to conceive that these modifications of man's body could have been evolved directly from a monkey-like ancestor; to come by them man must have passed through an anthropoid stage.

found that the blood of man and that of the great anthropoid apes gave almost the same reaction. The more remote an animal was on a structural scale, the less was the degree of reaction. Bacteriologists find that the living anthropoid body possesses almost the same susceptibilities to infections, and manifests the same reactions, as does the body of man. So alike are the brains of man and anthropoid in their structural organisation that surgeons and physiologists transfer experimental observations from the one to the other. When the human embryo establishes itself in the womb it throws out structures of a most complex nature to effect a connection with the maternal body. We now know that exactly the same elaborate processes occur in the anthropoid womb and in no other. We find the same vestigial structures—the same 'evolutionary post-marks'—in the bodies of man and anthropoid. The anthropoid mother fondles, nurses, and suckles her young in the human manner. This is but a tithe of the striking and intimate points in which man resembles the anthropoid ape. In what other way can such a myriad of coincidences be explained except by presuming a common ancestry for both?

The Evolution of Man's Brain

The crucial chapters in Darwin's "Descent of Man" are those in which he seeks to give a historical account of the rise of man's brain and of the varied functions which that organ subserves. How do these chapters stand to-day? Darwin was not a professional anatomist, and therefore accepted Huxley's statement that there was no structure in the human brain that was not already present in that of the anthropoid. In Huxley's opinion, the human brain was but a richly annotated edition of the simpler and older anthropoid book; and this edition, in turn, was but the expanded issue of the still older original primate publication. Since this statement was made thousands of anatomists and physiologists have studied and compared the brain of man and ape; only a few months ago Prof. G. Elliot Smith, our leading authority on this matter, summarised the result of this intensive enquiry as follows: "No structure found in the brain of an ape is lacking in the human brain; and, on the other hand, the human brain reveals no formation *of any sort* that is not present in the brain of the gorilla or chimpanzee. . . . The only distinctive feature

of the human brain is a quantitative one." The difference, it is true, is only quantitative, but the importance of the difference cannot be exaggerated. In the anthropoid brain are to be recognised all those parts which have become so enormous in the human brain. It is the expansion of just those parts of his brain which has given man his powers of feeling, understanding, acting, speaking, and learning. The essential problem of man's evolution is the rise of his brain; when we have solved this we have solved all.

The Evidence of Psychology

Darwin himself approached this problem not as an anatomist but as a psychologist, and, after many years of painstaking and exact observation, succeeded in convincing himself that, immeasurable as are the differences between the mentality of man and ape, they are of degree, not of kind. Prolonged researches made by modern psychologists have but verified and extended Darwin's conclusions. No matter what line of evidence we select to follow as regards the evolution of man's brain—evidence gathered by anatomists, by embryologists, by physiologists, or by psychologists—we reach the conviction that man's master-organ has been evolved from that of an anthropoid ape, and that in the process no new structure has been introduced and no new or strange faculty interpolated.

Unexplained Problems

In these days our knowledge of the elaborate architecture and delicate machinery of the human brain makes rapid progress, but I should mislead if I suggested that finality is in sight. Far from it; our enquiries are but begun. There is so much we do not yet understand. Will the day ever come when we can explain why the brain of man has made such great progress, while that of his cousin the gorilla has fallen so far behind? Can we explain why inherited ability falls to one family and not to another, or why, in the matter of cerebral endowment, one race of mankind has fared so much better than another? We have as yet no explanation to offer, but an observation made twenty years ago by one on whom Nature has showered great gifts—a former President of this Association and the doyen of British zoologists—Sir E. Ray Lankester—deserves quotation in this connexion: "The

leading feature in the development and separation of Man from other animals is undoubtedly the relative enormous size of the brain in Man and the corresponding increase in its activities and capacity. It is a striking fact that it was not in the ancestors of Man alone that this increase in the size of the brain took place at this same period—the Miocene. Other great mammals of the early Tertiary period were in the same case." When primates made their first appearance in geological records, they were, one and all, not only small animals but they were also relatively small-brained. We have to recognise that the tendency to increase of brain, which culminated in the production of the human organ, was not confined to man's ancestry, but appeared in diverse branches of the mammalian stock at a corresponding period of the earth's history.

That an increase in the relative size of brain, with an accompanying improved capacity to feel and to understand, is an advantage to an animal is manifest to all, but the factors which tend to produce such an increase we have not discovered as yet.

CHAPTER III

The Machinery of Man's Evolution

DARWIN'S CONCEPTION OF EVOLUTION ILLUSTRATED

I HAVE spoken of Darwin as a historian. To describe events and to give the order of their occurrence is the easier part of a historian's task; his real difficulties begin when he seeks to interpret the happenings of history, to detect the causes which produced them, and explain why one event follows as a direct sequel to another. Up to this point we have been considering only the materials for man's history, and placing them, so far as our scanty information allows, in the order of their sequence; but now we have to seek out the biological processes and controlling influences which have shaped the evolutionary histories of man and ape. What do we know concerning the machinery of evolution—the means by which new types come into existence? The evolution of new types of man or of ape is one thing, and the evolution of new types of motor-cars is another; yet for the purposes of clear thinking it will repay us to use the one example to illustrate the other. In the evolution of motor vehicles Darwin's law of selection has prevailed; there has been severe competition, and the types which have answered best to the needs and tastes of the public have survived. The public has selected on two grounds—first for utility, thus illustrating Darwin's law of natural selection, and secondly because of appearance's sake; for, as most people know, a new car has to satisfy not only the utilitarian demands of its prospective master, but also the æsthetic tastes of its prospective mistress, therein illustrating Darwin's second law—the law of sexual selection. That selection, both utilitarian and æsthetic, is producing an effect on modern races of mankind and in surviving kinds of ape, as Darwin supposed, cannot well be questioned. In recent centuries the inter-racial competition amongst men for the arable lands of the world is keener than in any known period of human history.

The Production of New Types

The public has selected its favoured types of car, but it has had no direct hand in designing and producing modifications and improvements which have appeared year after year. To understand how such modifications are produced the enquirer must enter a factory and not only watch artisans shaping and fitting parts together, but also visit the designer's office. In this way an enquirer will obtain a glimpse of the machinery concerned in the evolution of motor-cars. If we are to understand the machinery which underlies the evolution of man and of ape, we have to enter the 'factories' where they are produced—look within the womb and see the fertilised ovum being transferred into an embryo, the embryo into a fœtus, and the fœtus into a babe. After birth we may note infancy passing into childhood, childhood into adolescence, adolescence into maturity, and maturity into old age. Merely to note and register the stages of change is not enough; to understand the controlling machinery we have to search out and uncover the processes which are at work within developing and growing things and the influences which co-ordinate and control all the processes of development and of growth. When we have discovered the machinery of development and of growth we shall also know the machinery of evolution, for they are the same. What are the factors which control the development and growth of living things? Modern research is throwing light on them.

Machine and Animal Evolution Contrasted

If the simile I have used might sound strange in Darwin's ear, could he hear it, the underlying meaning would be familiar to him. Over and over again he declared that he did not know how 'variations' were produced, favourable or otherwise; nor could he have known, for in his time hormones were undreamt of and experimental embryology scarcely born. With these recent discoveries new vistas opened up for students of evolution. Let me illustrate this problem, for it lies at the very base of our modern enquiries. The moment we begin to work out the simile I have used and compare the evolutionary machinery in a motor factory with that which regulates the development of an embryo within the womb, we realise how different the two processes are. Let us imagine for a moment

what changes would be necessary were we to introduce 'embryological processes' into a car factory. We have to conceive a workshop teeming with clustering swarms of microscopic artisans, mere specks of living matter. In one end of this factory we find swarms busy with cylinders, and as we pass along we note that every part of a car is in process of manufacture, each part being the business of a particular brigade of microscopic workmen. There is no apprenticeship in this factory; every employee is born, just as a hive-bee is, with his skill already fully developed. No plans or patterns are supplied; every workman has the needed design in his head from birth. There is neither manager, overseer, nor foreman to direct and co-ordinate the activities of the vast artisan armies. And yet if parts are to fit when assembled, if pinions are to mesh and engines run smoothly, there must be some method of co-ordination. It has to be a method plastic enough to permit difficulties to be overcome when such are encountered, and to permit the introduction of advantageous modifications when these are needed. A modern works manager would be hard put to were he asked to devise an automatic system of control for such a factory; yet it is just such a system that we are now obtaining glimpses of in the living workshops of Nature.

The Machinery of Development

I have employed a crude simile to give the lay mind an inkling of what happens in that 'factory' where the most complicated of machines are forged—the human body and brain. The fertilised ovum divides and redivides; one brood of microscopic living units succeeds another, and as each is produced the units group themselves to form the 'parts' of an embryo. Each 'part' is a living society; the embryo is a huge congeries of interdependent societies. How are their respective needs regulated, their freedoms protected, and their manœuvres timed? In the evolution of man's posture and gait thousands of structures have to be modified simultaneously and in a direction which will produce a harmonious and effective result. How is this done? Experimental embryologists have begun to explore and discover the machinery of regulation. We know enough to realise that it will take many generations of investigators to work over the great and new field which is thus opening up. When this is

done we shall be in a better position to discuss the cause of 'variation' and the machinery of Evolution. Meantime we make progress.

The Machinery of Growth

If we know only a little concerning the system of government which prevails in the developing embryo, we can claim that the system which prevails in the growing body, as it passes from infancy to maturity, is becoming better known to us every year. The influence of the sex glands on the growth of the body has been known since ancient times; their removal in youth leads to a transformation in the growth of every part of the body, altering at the same time the reactions and temperament of the brain. In more recent years medical men have observed that characteristic alterations in the appearance and constitution of the human body can be produced by the action of other glands—the pituitary, thyroid, parathyroid, and adrenals. Under the disorderly action of one or other of these glands individuals may, in the course of a few years, take on so changed an appearance that the differences between them and their fellows become as great as, or even greater than, those which separate one race of mankind from another. The physical characters which are thus altered are just those which mark one race off from another. It is clear that we have here revealed an important part of the machinery concerned in the evolution of human races and of new types.

How such effects are produced we did not know until 1904, when the late Prof. E. H. Starling, a leader amongst the great physiologists of our time, laid bare an ancient and fundamental law in the living animal body—his law of hormones. I have pictured the body of a growing child as an immense society made up of myriads of microscopic living units, ever increasing in numbers. One of the ways—probably the oldest and most important way—in which the activities of the communities of the body are co-ordinated and regulated is by the postal system discovered by Starling, wherein the missives are hormones—chemical substances in ultra-microscopic amounts, despatched from one community to another in the circulating blood. Clearly the discovery of this ancient and intricate system opens up fresh vistas to the student of man's evolution. How Darwin would have welcomed this discovery! It would

have given him a rational explanation to so many of his unsolved puzzles, including that of correlated variations.' Nor can I in this connexion forbear to mention the name of one who presided so ably over the affairs of this Association fifteen years ago—Sir E. Sharpey-Schafer He was the pioneer who opened up this field of investigation and has done more than anyone to place our knowledge of the nature and action of the glands of internal secretion on a precise basis of experimental observation. With such sources of knowledge being ever extended, and others of great importance, such as the study of Heredity, which have been left unmentioned, we are justified in the hope that man will be able in due time not only to write his own history, but to explain how and why events took the course they did Man's brain is penetrating the mysteries of the universe, and may hope, by rational enquiry, to solve its own mysteries.

Conclusion

In a brief hour I have attempted to answer a question of momentous importance to all of us—What is man's origin? Was Darwin right when he said that man, under the action of biological forces which can be observed and measured, has been raised from a place amongst anthropoid apes to that which he now occupies? The answer is Yes! and in returning this verdict I speak but as foreman of the jury—a jury which has been empanelled from men who have devoted a lifetime to weighing the evidence. To the best of my ability I have avoided, in laying before you the evidence on which our verdict was found, the rôle of special pleader, being content to follow Darwin's own example—Let the truth speak for itself.

CHAPTER IV

Further Evidence and Some Unsolved Problems

IN the previous Chapter, which formed the concluding part of my Presidential Address, I have carried my readers to what may be called the verge of our present-day knowledge concerning the origin of man. For in these days students of the human body are concentrating their efforts on discovering the living processes which have cleared away from man's body the more patent marks of his simian origin, and replaced them by those which we call human.

When we mark the rise of the human babe within the womb we see that two opposite processes are at work. On the one hand we note, at every stage of development, that certain ancient structures appear and then disappear—structures whose presence can be accounted for only in Darwin's way. On the other hand, we see at every stage, from the earliest to the latest, another process at work; one which is introducing new features—features which could never have existed in the adult stage of any known type of animal. We see almost the same features make their appearance in the developmental stages of anthropoid apes. There is a recapitulation of ancestral history as the human embryo passes through its ripening stages, but this recapitulation is masked by the display of characters which are wholly of recent origin. Nor need this surprise us. What should we think of a builder who in the erection of a palace insisted on 'recapitulating' all the evolutionary stages which lie between a hut and a palace? In the development of the human body, as of that of every other living thing, we find a strict observance of the principle of economy. If an ancient feature is reproduced, it is because it is a necessary part of the scaffolding for the new.

An anthropoid ape is most human—most child-like—in its youngest stages; as it matures it becomes brutal and more distant from man in appearance and in behaviour. This is a matter of ancient observation, and many have drawn the

conclusion that there can be only one explanation—namely, that anthropoid apes are the degenerate descendants of ancient humanity. Three lines of evidence show us that this is a mistaken notion. There is, in the first place, the geological record, which leaves us in no doubt that life began in its simplest form, and as time went on became ever more complex, culminating in man's brain. We cannot conceive the evolution of man's brain without postulating a stage such as that represented by the anthropoid brain. There is, in the second place, the developmental record; man's body begins as a simple living cell, and ends in the highly complex structure it is. In anthropoid development we find no suggestion that a higher stage in development was ever reached. There is a third line of evidence: in various forms of primates, particularly among South American monkeys, we observe the same tendency as we see in the case of man—a tendency to retain in adult years the immature characters of youth.

We thus come to the consideration of a problem which is now under discussion, and has been particularly advanced by my friend Professor L. Bolk, of Amsterdam. Recently he has analysed the structural characters which are peculiar to man, and in scores of instances has succeeded in showing that these human characters appear as transient features in the unborn young of anthropoid apes. Man has come by many of his distinctive appearances through retaining in adult years features—new features—which make only a transient appearance in the anthropoid body. How such an inheritance was made possible is partly explained by the considerations set forth in the concluding chapter of this book—a chapter entitled "Capital as a Factor in Evolution." Developmental stages, far from always reflecting the past history of an animal, often foreshadow the possibilities of the future. In the anthropoid fœtus we see transient features which have become permanent in man's body; in the human fœtus, if we could read the human horoscope aright, we might obtain the means for foretelling man's possibilities in times to come.

In a lecture [1] given in 1923 at Charing Cross Medical School in Memory of Huxley, who was its pupil, I have touched upon Professor Bolk's researches, and reproduce here what I wrote then, because it bears closely on the problems of man's origin.

[1] "The Adaptational Machinery Concerned in the Evolution of Man's Body." Published as a Supplement to *Nature*, August 18, 1923.

The Genesis of Man's Special Structural Features

We need not be surprised, seeing how plastic and resourceful embryonic tissues are, to find most—but not all—of man's characteristic features appear in a modified form as transitional phases in the fœtal stages of man's nearest allies—the anthropoid apes. Man's outstanding structural peculiarities have been produced during the embryonic and fœtal stages of his developmental history; the corresponding and somewhat similar characters which appear in fœtal anthropoids become masked in these animals by the superaddition of coarser animal features, which develop as their intra-uterine life closes, and particularly as their adolescent and adult stages are entered. At birth the brain of the baby gorilla is almost as big as that of the human baby; but whereas the period of rapid growth continues in the human brain throughout infancy, the brain of the gorilla proceeds after birth at a slow pace. The human brain retains the rapid rate of fœtal growth for two years after birth. Prof. L. Bolk of Amsterdam, who has done so much to prove that man's distinctive characters represent a heritage accumulated in the fœtal phase of his development, has shown that the downward bend of the front part of the base of the skull, and the consequent backward position of the face, occur at an early point of development in all mammals. The cranial bend becomes undone and the face thrust forwards as development proceeds in all mammalian forms, save in man, in whom these fœtal features are retained until, and throughout, adult life. The nearest approach to the adult human form occurs in the fœtal stages of anthropoid apes. The fœtal cranial bend is not a primitive or ancient character; it was worked out in fœtal life; never, until the evolution of man took place, did this feature survive to reach an adult stage.

Let us take another feature—man's hairless skin, and in the case of the white races its comparative lack of pigment. In the chimpanzee fœtus, at the seventh month of development, the hair is distributed on the body exactly as in a baby at birth; there is the same long and fine hair on the scalp; the same smooth skin covered with a short, almost invisible down. The skin, too, which afterwards becomes deeply pigmented and black in the adult chimpanzee, at this stage is grey, tinged with a trace of brown. At a still younger stage the skin is almost free from pigment. The young of many of the higher

primates are born with fair hair—often tinged with red. Fair hair is a fœtal character of primates which has become permanent in Northern Europeans, and is found distributed sporadically in North Africa and Central Asia. Here again we see characters which were worked out in fœtal months passing on to become characters of adult life.

Such examples could be multiplied to a wearisome extent. I do not wish to minimise the number and importance of transient simian features which appear in the body of the human fœtus and infant; they are well known and of great significance. But I do desire to give a true interpretation to such human features as are represented by man's small face and jaws; his forehead, tending to be devoid of supra-orbital ridges; his large head poised on a long and relatively slender neck: they are features first produced in the fœtal stages of higher primates and now retained by man in his adult state. The tendency to preserve such fœtal characters is seen in certain genera of South American monkeys. But all the fossil progenitors of ape and man we have yet discovered have a face, jaws, skull, and neck of the more primitive and bestial type.

In Chapter II I have discussed some of the difficulties which envisage students of man's evolution. There is one, however, which I should have inserted there if time and space had permitted. It concerns the occurrence of 'parallel evolution'—a possibility which Dr. H. Fairfield Osborn has done so much to elucidate. Is it possible, as he and also Professor F. Wood Jones hold, that man and the anthropoids have arisen from a very early and a very lowly primate, and that each has come by its community of structure independently? Now, parallelism of evolution does occur, and we have evidence of its operation in the primates—in the very order to which man himself belongs. We are now quite certain that the early primates, which have given rise to the monkeys of the New World and to the monkeys of the Old World, parted company, and have remained separate and evolved independently since a remote geological date. How remote that period is the reader will grasp if it is recalled that, as stated in Chapter II, the divergence of the human and anthropoid stems has been attributed to the beginning of the Miocene period or even earlier (see Fig. 1, p. 10). The Eocene period, at which the old and new world primate stocks parted company, lies even farther beyond the Miocene period than the Miocene period lies

beyond our time. The primate stocks parted while their brains were quite small and simple, yet in the course of long ages the spider monkey of South America and the Langur monkey of India have come by brains which in point of size and complexity show many and striking resemblances. That is only one instance; many others might be cited.

How do we account for such cases of parallel evolution? In our ignorance we have to speak of tendencies—an evolutionary bias which leads in the course of ages to the production of an almost identical structural result in two animals which have been evolved from a simple and remote ancestor. That there is such a bias or tendency manifested in the evolutionary history of animals is undoubted, and we account for it by supposing that in the remote distant ancestor there lay latent a developmental tendency which became manifest long afterwards in some of its descendants. We know nothing of the underlying mechanism of such tendencies at present, nor do we know how they are influenced, but only of their existence. Those who have noted the progress made in recent years by students of heredity will recognise that the solution of this problem lies well within the bounds of possibility.

Yet, in spite of similarities in their brains, no one would mistake the Langur of India for a New World ape, nor the spider monkey for one of the Old World; for the body of each is marked by the distinctive features of its family. Man has not only all the classification marks of the Old World primates, but also those which distinguish the anthropoid groups. Even if we admit the possibilities of parallelism in his case, we have to postulate an anthropoid stage in man's evolution to account for the assemblage of characters he now possesses. Difficulties are not to be burked, but faced; and as the evidence now stands we must conclude that it is most unlikely that man's ancestor was a "separate" anthropoid: all we know compels us to assign him to a place in the common anthropoid group.

In expressing my belief in 'parallel' evolution, and thus accepting the opinion that the evolutionary course of a race may be determined by developmental tendencies inherent in its germ-plasm and in its tissues, I range myself with Huxley and deny myself an easy means of explaining how man came by his many perfections. For from the body of man Archdeacon Paley selected many of his most telling examples of

contrivance. If man by using his brain could make that of his child a bigger and better instrument, then there would lie within our reach a sure way of improving the mental ability of the human race. Were our simian ancestors a race of brain-users? Did they come possessed of skilled and shapely hands by manual training repeated through endless generations? If the effects of use were hereditary, then the explanation would be easy. Let us see what Huxley had to say on this matter. It was not until 1876, when he was in the fifty-first year of his age and at the zenith of his intellectual power, that he gives us a glimpse within his mind and permits us to see how he viewed teleology [1]—the science of adaptation. In the early spring of 1876 he gave a lecture in Glasgow, selecting "the hand" as his subject—the text which had served Sir Charles Bell for a Bridgewater treatise. How had man come by his hand? By what evolutionary means had the clumsy climbing anthropoid hand become the dexterous grasping hand of man? If Huxley had believed, as Lamarck, Spencer, and Darwin did, that "functionally wrought" modifications could become hereditary—that a simian stock, were it to use its arms and hands as man now uses his, would in the course of many generations come to have human hands and arms—then the evolution of the human hand was a comparatively easy problem. At no time of his life did Huxley believe that the effects of use or disuse did become hereditary. In 1890 he wrote: "I absolutely disbelieve in use-inheritance as the evidence now stands."

Having thus rejected the only known means by which useful or purposive modifications of the body can be brought about, we turn with some degree of curiosity to his lecture in Glasgow on the evolution of the hand. The exact title which he gave to his discourse was "On the Teleology and Morphology of the Hand." This is how he approached the problem of adaptation: "To be a teleologist and yet accept evolution, it is only necessary *to suppose that the original plan was sketched out—that the purpose was foreshadowed in the*

[1] Many of my friends have condemned the use of this word, which Paley employed to designate purposive design seen in living contrivances. He explained them as the work of the Creator, whereas all modern biologists explain them as arising not from an external supermundane influence, but by powers which are inherent in living tissues, and which research is now elucidating and will further elucidate. It is with this modern meaning I reintroduce a useful word—teleology.

molecular arrangements out of which the animals have come." Then twelve years later (in a letter to Romanes in 1888) he wrote: "It is quite conceivable that every species tends to produce varieties of a limited number and kind, and that the effect of natural selection is to favour the development of some of these, while it opposes the development of others, *along their predetermined line of modification.*"

Thus it will be seen that Huxley, on the evidence then at his disposal, had come to the startling conclusion that the shaping or controlling forces which, in due season, were to give man his hand, lay latent in the germ-plasm of that simian stock which ultimately blossomed into human and anthropoid shapes. In the writer's opinion, this statement still stands true; but herein he is at variance with Professor E. W. MacBride and Mr. Morley Roberts.

How Adaptations Appear during the Development of the Embryo

Since the time of Darwin and of Huxley our knowledge of the factors which take a part in controlling the development, and therefore the evolution, of the brain and of its appended sense organs, such as the eye, the ear, and the nose, has entered a new phase. We shall take the formation of the eye as our first example, because in design and execution it far excels any camera yet invented; it has been the theme of many a teleological sermon, and a consideration of its development will take us right to the heart of our subject—the origin of purposive or adapted structures. After the publication of the "Origin of Species," Mr. J. J. Murphy, of Belfast, cited the eye as a structure which could not be accounted for by any theory of selection then propounded. "It is probably no exaggeration to suppose," wrote Mr. Murphy, "that in order to improve such an organ as the eye at all, it must be improved in ten different ways at once, and the improbability of any complex organ being produced and brought to perfection in any such way is an improbability of the same kind and degree as that of producing a poem or a mathematical demonstration by throwing letters at random on a table."

Darwin, with that customary candour which regulated his search for truth, quotes in full this cogent and, to my way of thinking, just criticism; and Darwin's reply was that the eyes of men, as of animals, did show slight degrees of individual

variation, and that he could conceive the twilight eye of the owl or of the lemur as having arisen by a selection and accumulation of these minute variations. Mr. Murphy modestly estimated the parts of the eye which must undergo a simultaneous modification, if sight was to remain efficient, as ten in number; he would have been inside the mark if he had said ten thousand. We cannot conceive how the countless elements which go to the construction of an eye can assume their appropriate place, form, and function unless we postulate a machinery which regulates the development and growth of every one of them.

The existence of such a machinery was made evident by experiments on tadpoles carried out by Dr. Warren H. Lewis at Baltimore from 1903 onwards. The optic cup, which ultimately forms the retina of the eye, grows out from the wall of the brain towards the embryonic skin or ectoderm. When this cup comes into contact with the ectoderm, the overlying cells begin to proliferate and arrange themselves so as to form a transparent or crystalline lens. Dr. Lewis transplanted the outgrowing optic cups of tadpoles, and found, if they were placed under the ectoderm of the neck or of the belly, that the result was the same; an optic cup caused the overlying cutaneous cells to alter their nature and form a lens. Dr. Lewis realised the significance of his discovery; in the developing embryo, although only of certain species, one group of living cells can enslave and control the behaviour of another group. He gave us a glimpse of the kind of evolutionary machinery employed in fashioning a highly purposive structure such as the eye. Any one who has followed the success with which physicists have unravelled the structure of the atom in recent years will not despair of an equal success attending the efforts of embryologists to uncover the means by which one group of embryonic cells regulates the growth of a neighbouring group.

Our knowledge of the machinery by which the growth of embryonic tissues is controlled and shaped is likely to increase rapidly, for in recent years embryologists have copied the methods invented for the study of bacteria, and have succeeded in growing the live tissues of embryos in artificial media. It has been proved time after time that the epithelial cells of an embryo, such as the living cells of renal tubules, if grown apart from other cells, spread outwards in a more or less disorderly manner; but if connective-tissue cells are added to the culture, then the epithelial cells form orderly ranks, just as

they do in the kidney tubules of the embryo. Carrel found that the juices of embryonic tissues contain substances which cause cultures of living cells of any kind to proliferate rapidly and to continue alive for an endless series of generations. Thus it will be seen that the machinery which regulates the behaviour of groups of cells within the body of the embryo is one of the utmost complexity, and yet is of a kind which can be handled and studied by biologists. Nor can we doubt for a moment that the machinery of development and of growth which we find at work in the embryo is also the machinery of adaptation and of evolution. In every phase of the development and evolution of the human hand we see this adaptational machinery at work.

Behaviour of Young Nerve Cells

There is no need to tell even the uninitiated that the brain and nervous system of man comprises many thousands of millions of microscopic units or nerve cells. Each unit of the brain has its appropriate place in a tremendously complex system, and has its special duty in dealing with the tide of messages which flood that system in every hour of conscious and subconscious life. When a child is born all the nerve centres which regulate the complex apparatus of breathing start into instant and effective operation. When the mother's teat is placed within its lips the nerve centres which regulate this intricate series of actions start to work as if they had served an apprenticeship before they appeared in the orderly development of the babe's nervous system. We cannot yet explain satisfactorily the means by which such really marvellous evolutionary results have been reached, such as reflex nerve centres, ready for action at the moment of birth; but at least we can claim to have before us a prospect of giving a rational account of how the various groups of nerve units are assembled so as to give a functional result.

Our present knowledge of this matter is largely due to the researches of Dr. Ariens Kappers of Amsterdam, and to investigations made by his pupils. Nerve cells may not remain in the sites at which they are developed; in their younger stages they have the power to migrate. Dr. Kappers found that a group of embryonic nerve cells or neuroblasts, which are afterwards to control definite sets of muscles and therefore to be concerned in carrying out certain actions of the body,

migrate towards the sources of their information. Those young executive nerve cells take up their permanent stations at points most suitable for the performance of their life's work. If we conceive a mob of war-seasoned men to deploy automatically and to take up effective battle-stations, we have before us a picture of what is to be seen taking place among the nerve cells in the brain of the growing human embryo.

Purposiveness is an Essential Property of Living Matter

We cannot conceive living matter as devoid of purpose; to live it must find and take in nourishment, assimilate it and eject the refuse. To find the source of this essential quality we have to go to the very beginning of life itself, which is a quest still beyond the reach of our instruments of enquiry. That great biologist, John Hunter, gave utterance to an important truth when he said man's bony and vascular tissues retained the same automatic purposive behaviour as is manifested by the lowest forms of organised life, such as the hydra. In the formative period of the human embryo, and in the phase when adaptational contrivances are being worked out in its heart, brain, muscles, and skeleton, the embryonic cells retain many of the purposive, almost conscious attributes possessed by primitive unicellular organisms. No doubt the behaviour of embryonic cells, as of the simplest protozoa, will prove to be reflex in nature—mere protoplasmic reactions to appropriate stimuli. In bringing about the collective reactions of embryonic tissues, which mould them to form structural adaptations, we may presume that hormones play a leading rôle. The hormone system, to give the results it does, must be framed upon a teleological basis.

If we would rightly understand the evolution of the machinery of adaptation, or, what is the same thing, the machinery of government, in the developing body of an animal, we shall do well, as Herbert Spencer suggested, to study the evolution of a people rising from savagedom to civilisation. In the earlier stages of the evolution of human society we see that the machinery of government is represented by the automatic working of a herd-instinct—an instinct tending in all its operations towards the preservation of the community. The instinct is biased in the direction of producing functional or effective results. We have to study what, in our present

ignorance, we must call the "herd-instincts" of the vast community of protoplasmic units embraced by the body of a human embryo, if we would understand how the structural contrivances of the human body have been evolved. I, for one, believe with Huxley that the government which rules within the body of the human embryo proceeds along its way altogether uninfluenced by occurrences or experiences which affect the body or brain of its parents. In short, man has come by his great gifts—his brain, his upright posture, his strange foot, and his nimble hand—not by any effort of his own, but, like a favoured child of the present day, has fallen heir to a fortune for which he has never laboured.

CHAPTER V

Darwin's Home

[The Council of the British Association desired me, if an opportunity should occur at the end of my Presidential Address, to make an appeal for the preservation of Darwin's Home at Down. The opportunity came; I made an appeal; that appeal to audience and to Press had the most gratifying result. Next morning came a telegram from Mr. G. Buckston Browne, a Fellow of the College to which I also have the honour of belonging, offering to purchase Down House for the nation, endow it so that it would be preserved as it was when Darwin lived in it, and at the same time serve some charitable purpose for the poorer followers of science. The Council accepted this offer with gratitude, and resolved that this act of generosity should be known for all time as the " Buckston Browne Gift to the Nation."

The wireless message thrown out at Leeds cannot be called an S.O.S., for the Darwin family had resolved, particularly the present owner of Down, Professor C. G. Darwin, a grandson of the great naturalist, that so long as it was within their means Down House should remain unchanged. In seeking to make Down House a National Trust the Council of the British Association had no thought of establishing a memorial to Darwin; by his works he himself established a monument which the passage of time will but enhance. What the Council felt was the unfairness of saddling a family which has done so much for science with a permanent burden, while men of science who owe it so much stood by and did nothing to show their gratitude. Mr. Buckston Browne has paid our debts for us, and it will now be possible for students in coming centuries to warm their enthusiasm for research and for truth by visiting the scenes of Darwin's labours. We cannot know Darwin unless we know Down; living science can never be divorced from its great personalities. The essay here reproduced was written for the *R.P.A. Annual* of 1923.]

LONDONERS living on the northern heights often mark the Crystal Palace gleaming high above the south-eastern suburbs, but few know, or care to know, that only eight miles beyond, nestling in a hollow of the wooded chalk downs of Kent, is the village of Down, and near by Down House, where Charles Darwin, single-handed, wrought the miracle of the nineteenth century. For the man who changed the outlook of all thinking men throughout the world, and transformed the face of all kinds of learning, surely performed a miracle. But if the student of Darwin's works longs to

know the home in which they were produced, and the establishment of which their author was master, he will not easily come by a description of them. Yet to really appreciate and understand the writings of Charles Darwin it is essential to have a mental picture of their birth-place. It seems to me that this neglect of Darwin's home and of Darwin's life is symptomatic of an ignorance or indifference on the part of the rising generation of scientific men of how much they owe to Darwin and to Down. The day will assuredly come when Down will rival Stratford-on-Avon as a Mecca for pilgrims.

Readers of Sir Francis Darwin's "Life" of his father are familiar with the picture given there of Darwin's home at Down. Before giving quotations from that work I may remind my readers that prior to moving into Kent Darwin lived in Gower Street. He made his home there when he married, January 29, 1839, having then almost completed his thirtieth year :—

> On September 14, 1842, my father left London with his family and settled at Down. In the Autobiographical chapter his motives for moving into the country are briefly given. He speaks of the attendance at scientific societies and ordinary social duties as suiting his health so "badly that we resolved to live in the country, which we both preferred and have never repented of."
>
> The choice of Down was rather the result of despair than of actual preference; my father and mother were weary of house-hunting, and the attractive points about the place thus seemed to them to counterbalance its somewhat more obvious faults. It had at least one desideratum—namely, quietness. Indeed, it would have been difficult to find a more retired place so near to London. . . . It is a place where new-comers are seldom seen, and the names occurring far back in the old church registers are still known in the village.
>
> The house stands a quarter of a mile from the village, and is built, like so many houses of the last century, as near as possible to the road—a narrow lane winding away to the Westerham high road. In 1842 it was dull and unattractive enough; a square brick building of three storeys, covered with shabby whitewash and hanging tiles. The garden had none of the shrubberies or

walls that now give shelter; it was overlooked from the lane, and was open, bleak, and desolate.

The house was made to look neater by being covered with stucco, but the chief improvement effected was the building of a large bow up three storeys. This bow became covered with a tangle of creepers, and pleasantly varied the south side of the house. The drawing-room, with its verandah opening into the garden, as well as the study in which my father worked during the later years of his life, were added at subsequent dates.

Eighteen acres of land were sold with the house, of which twelve acres on the south side of the house form a pleasant field, scattered with fair-sized oaks and ashes. From this field a strip was cut off and converted into a kitchen-garden, in which the experimental plot of ground was situated, and where the greenhouses were ultimately put up.

No doubt Sir Francis Darwin had in his mind a clear picture of his beloved home as he penned these passages, but by reading them and re-reading them I could never obtain a concrete conception of the establishment which Charles Darwin set up at Down, and where he taught mankind how to study the world into which it has been born.

Hence it came about that in a gleamy morning of February, 1921, I found myself in the lane mentioned in Sir Francis Darwin's description, leaning against the flint wall which his father built to separate passers by from the frontage and approach to Down House. As I stood there, I instinctively began to count the windows in the stucco-visaged middle block, fifteen in all, five to each of the three floors. The two windows on the ground floor to my right I recognise as those of the old study in which the " Origin of Species " was written; the three in the same row to the left certainly open into the 'old dining-room'; the two rows of windows in the upper storeys mark the bedrooms. This older central block, ending above in a rather flat slate-covered roof, finished by rising chimneys, would have satisfied the needs of most men who have to depend on learning for a living, but it proved too small for the ever-growing Darwin family; hence continuing the central block to my right is the new wing. I note the plain hall door between the old and new parts which gave Darwin's visitors entrance when they passed through the

gateway in the flint wall, and made their way along in front of the new wing; between flint wall and the house there is only the carriage approach, flanked by a flower-bed and low shrubs. The two windows on the ground floor of this new wing look into the new study; just behind one of these windows Darwin sat daily at his dissecting table, or writing on a board resting on the arm of his easy-chair. Above the 'new study' more bedrooms. Then away to the left of the central block a gabled creeper-covered extension—the kitchen, scullery, and offices. Among the trees which shelter this end of the house and flank the roadway I can see a detached cottage, the home of the servant who acted as gardener, and on occasions as coachman when Darwin, in his earlier years at Down, drove to Sydenham to catch the train for London. Altogether an establishment of substantial appearance, which a passer-by on this country road would have assigned to the sporting scion of a county family. No one could have guessed it sheltered the greatest student England ever produced, and was the birthplace of some of her most lasting books.

Having duly counted the windows, I turn right about to realize that the house does not quite face the rising sun, but turns its front almost as much to the north as to the east; looking in this direction, I see below me the red-roofed village of Down with its church spire covered with grey wooden shingles. The village is built irregularly at cross roads, sheltered among tall elms, and only a meadow length away. I see that the lane on which I stand issues from the west side of the village, passes the pond and the blacksmith's shop, creeps along the hedge on one side of the meadow, and presently turns along another towards where I stand. Then, curving past Down House, the lane holds its way mainly in a southerly direction, until it is lost in the wooded hollows and ridges which form, some six miles away, the flank of the Kentish plateau. It is an easy step to the village from Down House. In search of a pinch of snuff at the vicarage Charles Darwin had not far to go; nor had the vicar far to come when he made one of his welcomed calls.

The sounds which issued from its windows on this February morning would have told me, had I not already known it, that Down House had become a school for girls—a young ladies' seminary. Presently I was within the entrance hall, which passage-like runs from front to back of the house. I

was introduced by a letter which Major Leonard Darwin had kindly given me. Near the far end of the hall one might turn to either the right or the left. The passage or corridor to the left passed behind the rooms I had surveyed from the outside; the first door on the left leads into Darwin's old study—where so much was accomplished—now a teacher's room, while beyond is the door of the old dining-room, now a schoolroom. This left-hand corridor ends in the kitchen quarters. On its right side opens the roomy staircase leading to the bedroom floors above; beyond the staircase, between it and the kitchen, opens the door to the 'new' and spacious dining-room. Through that door in days gone by came and went Joseph Parslow, Darwin's butler, for forty years an integral part of the family; from within the dining-room one can almost catch an echo of a large and laughing family—one of the happiest in all England—an echo of sixty years ago.

We have been standing in the far end of the hall looking to our left along the corridor of the old house; near here in olden days stood the hall table with its jar of snuff. On our right open two doors, through either of which Darwin was wont to issue as he came to refresh himself from the jar. The first door leads into the study, the new study, with its fireplace in the wall opposite to the door. At each side are the recesses where Darwin had his shelves and loose folios; one can see where the easy-chair stood between the far window and the fireplace, and the position of the flat table near the middle of the room, and the bookcase against the wall on the left. Just beyond the study door opens that to the drawing-room—the new 'new' drawing-room—of goodly proportions and well lighted from the verandahed window looking out on the shrubberied lawn behind the house. Who has not felt a tugging at their heart-strings when reading of the evenings which Mrs. Darwin and her husband have spent here? There is only a partition between this room and the adjacent study where Darwin, more than any man, helped to free the human mind from the shackles of tradition.

As is often the case in English homes, the back of Down House is really its front. Here we note one of Darwin's earliest improvements—the building out of the bow-windowed extensions of the dining-room and of his bedroom above the dining-room; the great mulberry tree, which met his glance as he looked out of a morning, still stands and flourishes; so do the great lime trees under which he loved to sit as his

children played tennis on the lawn; his gravel walks are still preserved.

On the side we are now examining, Down House catches the afternoon sun, for it faces the south and west. Away in these directions lie the eighteen acres of lawn, garden, and paddock of which Charles Darwin was master for almost forty years—the scene of his many experimental triumphs. It is an oblongish, uplandish strip of land, nearly 600 feet above sea-level, the road or lane from the village bounding it on the north and east; away in the south, the property ends at the brink of one of those deep round-bottomed, grassy valleys which everywhere cut into the Kentish plateau; on the west are neighbouring gardens and fields. Away, at this narrower southern end, just above the coppiced and meadowed valley beyond, is a belt of shrubs and trees, about three hundred yards in length and some fifteen or twenty in width, planted by Darwin. Round this belt runs a walk—the famous 'sand-walk' where almost every day, wet or fine, the bearded seer of Down took his midday walk and exercise. The Darwin children, bird-nesting and playing in the plantation, noted that the philosopher, as he came opposite a heap of stones by the side of the 'sand-walk,' kicked one on the path at every passing to keep a reckoning of his rounds. Often he was there early enough—he who, had he so chosen, could have been a man of leisure—to see the prowling fox slink home on a winter morning, his brain brooding all the while.

At 12.15 on this February morning of which I write, it is not difficult to conceive a vision of the patriarchal form of Darwin come stepping across the lawn as he sets out for his accustomed walk before lunch-time, followed by his half-bred retriever dog 'Bob'—him of the 'hot-house' face. As we follow his footsteps westwards across the lawn, towards the garden and the greenhouses built against the high brick garden wall, I long to ask him about a stone, shaped like a bench-mark, which has lately been dug up in the lawn. Was it part of his work on earthworms—the forty years' study he brought to the point of publication the year before his death? To-day 'Bob' could hardly forget his manners so far as to put on his 'hot-house' face, for we are received at the greenhouses by a trousered handsome 'land girl.' The years of war have been hard, and Darwin can hardly expect to find experiments on foot in the greenhouses which in his

day teemed with them. To the right of the greenhouses, built into the garden wall, is the great tower-like structure, which he erected to test the effect of various kinds of rays on plant life; this we find still intact, but derelict.[1] We pass southwards along his garden, still well tilled, and note through an opening in the high brick wall his orchard and hard tennis-court beyond. Still holding our way along the garden on a narrow walk edged by high borders of boxwood, we soon see before us the 'sand-walk,' round which we shall leave the shade of the beloved Charles Darwin to wander. On our left between the 'sand-walk' and the house is the paddock where Darwin's pony and cattle grazed, now full of joyous girls, in full swing in a full-throated quickly moving game of hockey. Beyond the paddock a farm cart is plodding southwards on the road leading to some farm on the edge of the Downs to the Weald. Just beyond the road, looking still towards the east, there comes into view the tiled roof of a comfortable Jacobean farmhouse nestling among its trees, just as it did in Darwin's time, and in that of his grandfather Erasmus and other northern and western forebears.

Thankful am I that I have seen Darwin's home so well preserved as it is, and deeply indebted for the gracious reception which met me there. But what of the future? Since my visit the property has been in the market, with what result I have not learned. What if a future owner is one who knows not Darwin, and is all unconscious that he has become the absolute owner of the Nazareth of Evolution?

[1] Major Leonard Darwin, who has been so good as to read the proofs of this article, informs the writer that this tower-like building was put up to get views of the setting sun, and was never employed for the purposes mentioned in the text. As this left the elaborate machinery of shutters in the roof unexplained, I asked for still further information. Major Darwin obtained the following statement from his brother, Sir Horace Darwin, concerning this erection, which was known to the family as 'Bo-peep': "Bo-peep was the pigeon-house used by father when he was experimenting with pigeons. It originally stood somewhere near the well—exactly where I do not remember. It was hoisted to the top of the wall . . . because father did not know what to do with it and thought it would be a nice place to see sunsets from. I do not believe arrangements at the top for letting in different kinds of light existed." I have allowed my original statement, given to me by my guide, to stand, as the apparatus I noted must have been put up for some special purpose. I also desire to draw attention to the fact that, if we have difficulty in understanding the equipment of Down House now, it will be impossible to understand it when this generation is gone.

Is it not right that this pulpit from which Darwin spoke to all the world should become the home of a national Darwinian experimental garden? Surely something of the spirit of Darwin, the father of modern biological knowledge, hangs still over the place. The simple means by which he won such great results are still there, calling aloud for utilisation. But failing this scheme for its preservation, why not have prepared and published an accurate big scale plan of the battlefield on which Darwin won his peaceful victories? I have a hope that Major Leonard Darwin may add this to his many public services.[1] A thousand years hence studious men will pray for the information which can be furnished so easily now.

I set out with the intention of enumerating in this article the signs and circumstances which make me believe that not only the general public, but the vast body of scientific men, have grown indifferent—nay, ungrateful—to the incalculable benefits which Darwin has conferred on them. Their attitude to Down House is only one of them; I have a long list, but they need the brain and pen of Huxley to do them justice. It is more true to-day than in 1888, when Huxley wrote to Michael Foster thus:—

> I am getting quite sick of all the paper philosophers, as old Galileo called them, who are trying to stand on Darwin's shoulders and look bigger than he, when in point of real knowledge they are not fit to black his shoes. It is just as well I am collapsed, or I believe I should break out with a final 'Für Darwin.'

I should like to see Huxley again unleash his 'war dogs' on the 'paper philosophers' who now flood the pages of scientific journals, and on the literary men who pass glib and complacent judgments on Darwin. There would be a rare scuttle for shelter in their respective hutches and kennels! And yet it is not by the forceful Huxleian methods that Darwin is to win his final victory. He is to win by his sheer love of truth and the devoted pains he took to find out where the truth lay. Above all, he is to win because of the sweet reasonableness of his personality; his happy spirit came

[1] Major Darwin prepared plans of Down House and of the grounds which are now in the keeping of Mr. V. Plarr, Librarian to the Royal College of Surgeons.

nearer a true ethical ideal than that of the saintliest bishops of the nineteenth century. And yet the rising generation passes his writings by unread and his personality unappreciated.

More than other classes of professional students, men who are investigating problems relating to the origin of mankind and to the beginnings of religious creeds owe a daily debt to Darwin and to Huxley. Because of the victories gained by these pioneers in the 'sixties' and 'seventies' of last century, anthropologists can now go about their lawful vocations untrammelled by tradition and unparalysed by prejudice. It is to Darwin more than to any other thinker or writer that scientific men in England owe their present-day liberties.

If I had to cite a crowning example to justify our capitalistic system, I would bring forward the life and works of Charles Darwin. He conquered the indulgences and temptations which beset inherited wealth, and, in the surroundings I have sketched above, gave the world an untold fortune of knowledge in return for a limited allowance of capital and leisure. He wrecked his health for the good of humanity. It may be soon or it may be late, but assuredly the morning will dawn when England will wake up to its neglect of Darwin.

CHAPTER VI

Why I am a Darwinist

[This essay was contributed to the *R.P.A. Annual* of 1922. At this time and subsequently there was going on, in the public press, an unscrupulous campaign conducted in such a way as to convey to the public the impression that scientific men had weighed Darwin in their modern balance and found him wanting. In the preceding essay is given a quotation to show what Huxley thought of Darwin's early critics. His castigation may well be reapplied in these times.]

EIGHT years ago Professor Gilbert Murray made his Presidential Address to the Classical Association an intimate exposition of the creed or religion of a man of letters. It is beyond my powers of expression to throw into words the guiding motives of the men who are giving their lives to discover the nature of the universe of which mankind has wakened to find itself a part, but I may speak for the smaller band of searchers who are busily engaged in tracing man's pedigree. This band, almost without exception, shares the creed and faith of Charles Darwin. Our faith is that by a patient gathering of evidence we can answer the question: 'Whence are we?'

I am glad to have an opportunity of summing up the evidence on which an answer to this question must be framed, for this reason: there is a real present danger that men who, by the nature of their employment or by the privilege of wealth, as was Darwin's case, are investigating the evidence relating to man's origin, move so far in advance that they lose touch with the great public, who, in reality, provide research workers with their livelihood. Every investigator owes a debt to the community in which he lives, and should render an account of his life's work. The mere fact that Mr. Chesterton and Mr. Hilaire Belloc could confidently assure readers of the Sunday Press that Darwin's theory was dead showed that those who are studying the evidence of our origin, and who are Darwinists to a man, had lost touch with public intelligence.

What, then, did Darwin do, and what is his theory?

Business men will understand me when I say Darwin made Evolution a 'going' concern. Many men before Darwin's day had tried to float Evolution on the market of human intelligence, but the public examined their prospectuses and refused to subscribe the needed capital. It was different when Darwin floated his scheme of Evolution: experts at once saw his was a profit-earning concern, so put up the money and have never had cause for regret.

There was another service which Darwin—or rather I should say which Huxley and Darwin—rendered to Evolution. They made it possible for us men of to-day to pursue our studies without persecution—without being subjected to the contumely of Church dignitaries by being asked whether it was on our father's or on our mother's side we traced our descent from apes!

One third service Darwin rendered to mankind. Until he came men believed that the miracle of creation took place long ago, and in a distant place; he produced convincing evidence which shows that miracles have not ceased; they are taking place here and now; creation has been, is now, and ever will be a condition of human existence. Evolution is at work at this day among us, and among all the people of the world.

What, then, is Darwin's theory of man's origin? To grasp its essential features the reader must bear in mind, as Darwin always did, the way in which new breeds of domestic animals are produced. Two factors are necessary—one within the bodies of the animals, tending to produce new features and fresh qualities; another the breeder, selecting and preserving the individuals which approach his new ideal.

In seeking to explain how man and ape had been evolved from a common ancestor—for this is an essential part of his theory—Darwin had no difficulty in showing that in the jungle, just as in the city, there is an unceasing struggle and a never-failing selective agency at work. Among apes and men Darwin's law of natural selection takes the place of the breeder. But he had a real difficulty when he came to explain how man had come by his distinctive features of face and body. With his native humility, Darwin admitted that the effects of use and disuse, of climate, food, or drink, could not explain why the negro features had been given to one race of men, Mongolian to another, and European to a third. Herein modern discovery has come to Darwin's aid by show-

ing that in the body of man and ape there is an adaptational machinery at work—the machinery of hormones.

Those accustomed to ecclesiastical theories may ask: If you introduce the action of hormones, is the theory Darwin's any longer? Ecclesiastical theories, like Lot's wife, look ever backwards, and are fixed into pillars of salt, which it is counted sacrilege to meddle with. Theories favoured by thinking men nowadays are living, growing children, ever in need of new garments. A boy fitted with a larger pair of trousers is still the same lad. If we shape a new pair of trousers out of hormones and fit them to Darwin's theory, it is none the less Darwin's child.

Why is it that men who investigate the body and brain of man, and their behaviours under health and disease, are convinced followers of Darwin? These are our reasons: When we watch the development of the body before birth we see it pass through a series of stages which we can explain only by supposing that man has had the lowliest of origins; he passes through the same phases as apes do—all save the final ones, wherein man and ape differ. We see his master organ, the brain, begin in the same way as in lowly animals, and then rapidly assume its dominant size and power.

When we examine and compare the architecture of the body and brain of apes with that of the human body we find so many features in common that we are driven to suppose that we are dealing with modification of a type which prevailed in a common ancestor. When we wish to study the nature of infectious diseases peculiar to man we have to resort to anthropoid apes, so human-like are their susceptibilities. In captivity the chimpanzee becomes subject to the fashionable disease—appendicitis. When we stand in need of help in mapping out the functional areas of the human brain the anthropoid ape again comes to our aid. How does the anti-Darwinist explain all these facts?

Then, again, when we examine races of mankind how are we to account for them? Here the upholders of the Mosaic account and the Darwinian theory are on common ground: both believe they are children of a common ancestor; the difference is that while the one holds the races of mankind to have been evolved during a space of some 6,000 years, the other demands a long geological period. Long before the Mosaic account was written there were Jews, Gentiles, and Ethiopians in Egypt.

Supporters of the Mosaic account believe that there is only one authentic history of the world—the inspired one. Geologists found out long ago there is another history. Ever since there was running water on the face of the earth nature has kept a faithful account of her living things. Fleet Street journalists, recording the events of the day, forget that the neighbouring river is also keeping a daily account. Never a day passes but some token of our present-day civilisation is swept into the mud of the Thames. Long before London came into existence our river had been treasuring up and preserving what fell into her lap. Ancient river beds, known as terraces, stretch now along the sides of the Thames valley as in every valley of the world, and in them we can read long past records.

This, then, is how Nature keeps her history, and when we turn to her pages and unfold them we can follow man's culture back to the crudest beginnings in a distant geological past, compared with which the Plain of Shinar and the Tower of Babel are but things of yesterday. In these same pages we find fossil remains of extinct kinds of men, and of beings which are mixtures of ape and man. How are we to explain these facts unless Darwin's theory be true?

One final word. Men and women whose judgment carries weight with me have asked this question: Does not a belief in Darwin's theory have a degrading influence on man's outlook and action? My answer is: Look into Darwin's life and see if a more humble and public-minded man, a man of more faith and charity, a better Christian in word and deed, was to be found in England during the nineteenth century than he. The most objectionable person we meet with in life is the one who presumes on the privilege of birth—often based on a conscious or unconscious delusion. The mark of the snob is that he fears the truth. Who, looking at the proceedings of our divorce courts and police courts, can deny our humble origin?

The man who keeps his eye on the barometer of his conscience will be the last to say that only angelic thoughts and feelings are native to us. Nay, we have something to gain by laying our humble origin to our hearts, for of humble origin mankind certainly is.

It is in no spirit of parody that the Darwinist claims "that men may rise on stepping-stones of their dead selves to higher things"; it is a doctrine which is literally true for him.

We get to know more and more of our dead selves as inquirers like Head and Sherrington unravel the structure and action of the elaborate machinery of our brain and mind. The underworld of the human nervous system laid bare under the stress of modern warfare cannot be understood if we proceed on the theory that we are independent and recent creations; but they fall into a natural system if we suppose that we have struggled up from the slums of the jungle.

The problem of unravelling man's past is an easy one compared to the establishment of a rational system of prophesying what he may become. We shall rise to higher things, and yet the one postulate which may be asserted with some degree of confidence is that man can never become a merely rational machine—one obtaining the zest for life by the exercise of higher mental faculties used in a purely unselfish way. The more we come to know of the 'make-up' of the nervous systems of men and women, the more we realise that the deepest and most lasting interests and pleasures of our lives are old instincts which are deeply implanted and of very ancient origin in the animal world.

CHAPTER VII

Capital as a Factor in Evolution

[This essay, contributed to the *R.P.A. Annual* of 1925, expounds an idea, not wholly a new one, which I should have liked to include in my Presidential Address had there been time. Men of science may be divided into two groups. Those of the first group, the smaller, spend their time in discovering how the forces of nature can be harnessed for the service of mankind. Such men have placed electricity and wireless at our disposal. The larger group of scientific men devote their lives, not to the discovery of new powers or the making of inventions, but to finding out how inventions have come into existence. Often the technician, with no knowledge of the principles involved, passes ahead of the man of science and invents a contrivance which, on scientific grounds, was believed to be an impossibility. Lord Kelvin held that a 'heavier-than-air' flying machine was of this nature. When aeroplanes succeeded scientific men were presented with many problems which required explanation—practice having moved in front of theory. We who spend our lives in the investigation of living things do nothing but unravel and explain 'Nature's' contrivance or inventions. Evolution implies a continuous process of invention; we have first to discover the mechanism of such contrivances, and then find out how they became possible. Such will be our labour to the end of time. As our knowledge progresses many inventions which we think man had made for the first time we discover, as we proceed, have been wrought in Nature's workshop millions of years before man came into existence. 'Capital' we usually regard as a modern discovery; this essay is to show that in the evolution of man 'Capital' has been a factor of the utmost importance in making his emergence possible.]

SOME time ago a company of Fellows of the Royal Society met round a table at lunch-time. One of them produced from his pocket—as a curio—a writing tablet; it consisted of a celluloid or celluloid-like film set in a thin metal frame. The owner, taking a match from his pocket, wrote his name on the film—the letters appearing as a dark-blue script. On withdrawing the film through a slot at the bottom of the frame the writing vanished. The film could be replaced, written on and so made to do duty for an endless number of times. The owner did not know how the effects were obtained, nor did any of those sitting round the table—after a close examination—fathom its mechanism. We were witnessing what seemed to us for the time being a magical or supernatural phenomenon—because it was one we could not explain; it seemed to lie outside the laws which regulate physical processes. Yet when the explanation came we found the puzzling effects

we had witnessed were produced by the simplest of mechanical processes.

I could not help being struck by the similarity of this experience to those which investigators of living matter—including students of the human body and brain—are brought face to face with every day. Take, for example, the evolution of such structures as the human eye or ear; by what purposeful processes were these wonderful contrivances brought into being? It would be idle to pretend that we have yet discovered the exact machinery which brings such elaborate instruments into existence. One feels certain, however, that our failure to fathom these secrets is not because the phenomena we seek to explain are magical or supernatural, but simply because we are still relatively ignorant and that our minds are still absolutely obtuse. When the explanation comes, as come it will, we shall find, as in the case just cited, that the means used in Nature's workshop are surprisingly simple and really not difficult of comprehension.

Some years ago [1] I sought to interest biologists in the old problem of adaptation, particularly as seen in those living structures which show design or contrivance. Many examples of this kind may be studied in the human body. To what extent does our present knowledge help us to understand the manner in which such structures have come into existence in the course of evolution? No one doubts that these contrived organs have been evolved, and that the processes which have given origin to them are still at work under our eyes. I set out my facts and arguments in a lecture which was given in Huxley's memory at his old school, that of Charing Cross Hospital. In this lecture my chief aim was to show that the discovery of 'hormones' had placed a new and powerful instrument in the hands of evolutionary biologists. For hormones play a very important rôle in the regulating of growth and in the shaping of organs and structures of the animal body.

To understand how hormones produce their effect, and the manner in which new adaptations arise, I saw that we must cease to look on the developing human embryo and the growing child as a simple individual; we must again take up Herbert Spencer's point of view, and regard the body of the embryo and of the child as a colossal community of microscopic living units.[2]

[1] "The Adaptional Machinery Concerned in the Evolution of the Human Body," *Nature*, August 18, 1923 (Supplement).

[2] See *R.P.A. Annual*, 1924.

As I worked at my Huxley Lecture I became more and more impressed with another factor which seemed to me to have played a most important part not only in the evolution of man's civilisation, but also in the evolution of all higher forms of animals and plants. Capital, using the term as business men use it, is a discovery of recent date, so far as our civilisation is concerned; but in this article I shall seek to show that capital was discovered by simple unicellular organisms when the world of life was still young. We shall find that in every branch of the animal kingdom the evolution of the highest forms has been made possible by exploiting the potentialities of capital—capital being represented by stores of surplus food. Indeed, I am of opinion that all the advances which have raised us from a simian stage to our present state of evolution have been introduced during developmental stages when the developing human body is dependent on a supply of nourishment provided by the maternal body, and that such advances —or inventions if you like—could not have been made if Nature had not worked out a scheme which gave the human young a prolonged pupilage. The thesis which I want to maintain is that for progressive evolution in animal life, just as in human civilisation, capital is necessary.

John Hunter, whose great museum it is my duty and privilege to tend, surmised that our hive-bees must have been evolved in a cold climate, as otherwise one could not account for their instinct to lay up a store of honey to carry them through the winter. What is true of bees is also true of men; our forefathers who survived the rigours of Northern Europe before the art of agriculture and the rearing of herds had been introduced were those in whom there was a tendency or an instinct to save. We recognise that races of mankind who are natives of the colder temperate regions are more prudent than those who live in lands where all the year is summer and plenty. There is in most of us a wish to save something from our daily income, be it large or be it small, to carry us over days of dearth or of sickness. We save too for quite another purpose—namely, to give our children a start in life, to give them free years for education and special training for the business they are to follow. And if it so happens that those parts of unconsumed wages, salaries, or incomes—that is to say, our savings—are not required for instant use, then we consult the financial columns of a newspaper, or procure a stockbroker's list, and presently our savings are turned into capital. Before we realise it, our savings are being used to

build a merchant ship, or perhaps a battleship, or a cotton factory, or a railroad, or a new sewage instalment. Our savings are being used to pay men to carry on the progress of civilisation in our town, our country, or our colonies. We advance upon our savings : our roads, our streets, our railways, our ships, our whole civilisation, have been built by our united savings or capital.

Much more important for the purposes of my present argument are the uses of capital, not in permitting us to develop well-known inventions and legitimate business propositions, but in providing the nests in which inventive genius may brood. All seats of learning such as universities are, or ought to be, nests of this kind. Universities have been built out of savings. Let us cite an instance: Glasgow University provided James Watt with suitable opportunities to develop his ideas, and he gave us the steam-engine as a return. The same university gave Lord Kelvin the means of making submarine cables a success, and of turning the sailor's compass into a reliable instrument. As another instance we may name the Royal Institution, which was built by savings of poor men as well as of rich men, and it was while working in its laboratories that Faraday placed a new and great power—electricity —at man's disposal; and it was in the same nursery that the great inventor Sir James Dewar opened up new paths to practical knowledge. It was while living on inherited savings that Charles Darwin wrung from living Nature some of her greatest secrets; his cousin Francis Galton lived on savings while he sought a way for man to lift himself to better things. Many an invention has been made on scant savings, sometimes on borrowed money.

Only those who have looked into the conditions of life among primitive peoples—and amid such conditions our forefathers lived only a few thousand years ago—realise the part which savings or capital have played in the rise and progress of our modern civilisation. We can study such conditions in any Australian tribe which is still remote from the white man's rule. Such a tribe can be said to own a certain tract of land, and the scanty supply of herbs, fruits, insects, and wallabies yielded by that tract of land; but they have no savings or capital. They depend from day to day upon what they can gather or catch. Each man, woman, and child owns in movable property just what they stand up in. There is but one occupation: the daily search for a livelihood. They could not, even if they would, build a hut or till a piece of land,

for such an enterprise needs a store of food—which is capital. They cannot carry on war, for we all know to our cost that war not only needs capital but often, as in our case, the power of mortgaging our savings for years and years to come.

Certain cemeteries in Upper Egypt, where the dead were laid to rest some six thousand years ago, give us the oldest glimpse we yet have of capital in actual use by man. In these graves we find food vessels wrought by skilled potters; we find also the husks of cultivated grain, bones of domesticated animals, woven linen, and highly elaborated implements of stone. We here see that in Egypt at this early date men had ceased to be wanderers; they had become settled in communities, had learned how to grow crops, rear cattle, and thus were able to amass savings from what was left over after their daily needs had been supplied. With what meal and meat they had left over they could afford to feed the men who specialised in making pots, looms, or implements. We may be certain that the chiefs buried in these pre-dynastic Egyptian village cemeteries collected their tithes and built their tithe-barns, and, on the tribal savings thus amassed, kept men to dig irrigation canals, build boats, and to work out artistic designs or ornaments, clothing, and household utensils.

It is most remarkable that in this first glimpse we get of man as a saving animal he should be applying his wealth, not for the comfort of the living, but for the welfare of the dead. Much of the savings of Ancient Egypt was spent in fitting out the dead with permanent supplies and durable habitations. We still spend some of our savings in the same way—on tombstones, statues, scholarships, almshouses, and Universities. This is a purely human custom; nowhere in the animal kingdom is capital put at the service of the dead.

Even so late as the days of Joseph we find the Egyptians storing their wealth, not in banks, but in granaries. With such resources the Pharaohs of Egypt could fit out armies to carry on prolonged campaigns. Later on came the great discovery that a lump of gold could stand as the equivalent of a certain number of sacks of grain, and men agreed that it was just as good to save gold as to save its equivalent in barley. Then came the modern discovery that a piece of paper printed in a certain way and issued under certain conditions could serve the same purpose as gold. With the discovery of money it became no longer necessary to hoard savings in the form of food, drink, or goods; the man or woman who owned money could tap the public supply or savings of food in any

and every market. We shall see that in the course of animal evolution the same end was secured without the use of money.

In the foregoing part of my argument I have been seeking to show that man has risen from savagedom to civilisation on his savings; his advance began when he discovered how to amass and preserve a surplus of food. We now turn to see the part which a similar but infinitely older discovery has played in the evolution of the higher animals, of which man is one.

The tendency to save something from one meal to tide over the interval between it and the next is as old as the evolution of living things. In simple unicellular animals, such as the amœba, certain granules are stored in its body; these granules we may truly regard as savings—food or fuel which the amœba will presently utilise. When we pass a step higher in the scale, to a stage where the progeny of a single cell, instead of separating and leading lives independent of each other, remain clustered together, so as to form a society of microscopic units, a state represented by sponges, we find the saving habit is still preserved, especially by certain individuals. As we ascend the scale still further, and to a stage where the society of cells has become so united that we speak of the community as a single animal, we find that there is one kind of cell which has acquired the saving habit much more than any of the others—namely, the cells of the female body which are to serve the purposes of propagation.

These living units of the female body we speak of as ova or eggs; what they save from their immediate needs they store up in the form of yolk. Yolk represents the savings or capital of the female reproductive cells; the yolk thus stored up is set apart for exactly the same purpose as the money a man saves for the rearing and education of a child. In the egg of the fowl this yolk-saving habit has reached a prodigious degree. In passing down the oviduct of the fowl the yolk has added to it a further store of capital represented by the white egg. Every one recognises that the yolk and white within an egg represent the capital on which a chick is reared. During the period of development a chick is freed from all duties of food-finding; it is placed in absolutely ideal circumstances for making evolutionary experiments, for the success or failure of such experiments does not come to the test of practice until the period of hatching is over. Progress requires leisure, and we can have no leisure unless we have command of savings or capital.

The fowl's method of providing capital for the production of a chick is primitive and clumsy, although the invention of

any other method would render our breakfast table the poorer. The position of the fowl's egg in the evolution of capital corresponds to the stage reached in Ancient Egypt, where wealth was stored in the form of grain. The same stage is represented—or rather, I should now say, was represented—by the stores of oatmeal, potatoes, and cheese which Scottish students brought from upland farms when they descended on their lowland universities; stores which were sufficient to carry them through a winter session. The student's provisions represented savings from his father's farm; on these savings he could apply himself untrammelled by bread-earning to the serious work of acquiring knowledge of men and things. In more modern days the father sells the savings from the farm and gives his student-son a draft on a bank in Edinburgh, whereby the student can draw upon the stocks of food and learning which are stored in that city. And later still Mr. Carnegie, by placing a large share of his savings at the disposal of these same students, has made it possible for every one of them to tap the stores of learning preserved in the four universities of Scotland. We shall now proceed to show that a very similar series of events in the evolution of the use of capital took place in the rise and progress of the higher mammals.

To understand the sequence of events which placed so advantageous and so prolonged a budding period at the disposal of higher mammals, we have to descend to a group of fishes which there is good reason to think lie near the ancestral line of the higher vertebrates. They remain on or near the evolutionary route taken by the higher mammals in the early days of vertebrate animals. This low group—which we may speak of as Selachians—is made up of sharks, rays, and dog-fish. It is over forty years since that very brilliant and young genius, Francis Maitland Balfour, younger brother of Lord Balfour, discovered that the key to most of the obscure problems which surround the development of higher vertebrates—including man himself—was to be found by studying the embryology of Selachians. This is particularly true of the structures which permit the young of higher mammals to draw their nourishment from the womb of the mother. The whole story of the evolution of the placenta is told in the plainest manner—not by adult sharks and dog-fish, but by their developing young. We shall see that the placenta, one of the most marvellous of evolutionary inventions, was worked out in the larval or developing period of the Selachians.

Let us take the living egg of the common dog-fish to begin

with. It has acquired the yolk-saving habit to a high degree. The fertilised egg is passed out into the sea enclosed within an elaborate horny shell. To envelop the yolk and to mobilise it for the use of the embryo a part of the bowel is prematurely developed and forms a living sac or purse for the yolk. The abdomen of the embryo is too small to accommodate the large yolk sac; hence this structure hangs suspended from the belly of the larva, surrounded by a covering or envelope derived from the wall of its body. The yolk sac and its covering form a real hernia, or projecting pouch, attached to the belly of the larva. When the end of the larval period approaches and the young dog-fish is preparing to escape from its shell, the yolk sac becomes gradually emptied of its contents and the hernia is reduced and disappears. The dog-fish, like the chick, has been reared upon the maternal stock of savings represented by the yolk.

In another Selachian fish studied by John Hunter the egg is no longer extruded, but hatched within the mother; the yolk sac of the embryo is covered with blood vessels, and is thus able to absorb a certain amount of nourishment from the lining membrane of the maternal tube or womb in which the developing larva is enclosed. Then, in another species of dog-fish, a further stage in evolution of larval nourishment is found. The egg is not so heavily laden with yolk, but as the larva develops in the maternal tube or womb the yolk-sac hernia already mentioned becomes elongated into a tube-like sac with a dilated end. The yolk sac lies within the hernia; it is surrounded by a loose covering formed by prolongations or premature overgrowth of the belly wall of the larva. The outer coverings of the yolk-sac hernia is alive with blood vessels filled from the heart of the larval dog-fish. The vascular covering at the free end of the hernia becomes thrown into folds; so does the vascular lining of the mother dog-fish's womb. The folds of the hernial sac interlock with those of the mother's womb; larval blood runs side by side with the mother's blood, and draws nourishment and oxygen from it. The larval dog-fish thus taps the floating capital of the mother's body. It lives on the surplus circulating savings of its mother's body.

Here we have in the evolution of the yolk sac and placenta the same three stages in the evolution and use of capital as were illustrated by examples drawn from Scotland. In the ordinary dog-fish the larva is reared on the yolk saved by, and stored within, the body of the maternal egg-cell; in the third

example, where the larval hernia or placenta effects a junction with the womb, and where the fluid, circulating pabulum, or capital of the mother's body is put at its disposal, we have an illustration of the Carnegie endowment. The larva secures a constant and sure food supply during the period it is preparing for the stern duties of life.

The most outstanding feature in the earliest stages of development of the human embryo—and the same is true of the embryos of anthropoid apes—is the exuberance and the prematurity with which the yolk sac, and particularly the coverings of the yolk sac, are developed. All the preparatory changes which are seen to come about in early stages of human development are intended to set up that enormous scaffolding of living tissues which permits the embryo to draw its supplies direct from the floating capital of the mother's body. For nine months the developing body of man is nourished and nursed within the womb; it is freed from all the anxieties which attend the struggle for a livelihood. This intra-uterine period is one which gives every opportunity for the working out of new inventions. Nay, in my Huxley Lecture I have sought to show that it is just in this period that the new and characteristic features of man's brain and body are invented and worked out.

It is true that man's developmental period of nine months is no more than that possessed by the great apes to whom, in structural features, man is so near akin. In them, in him, and in all mammals there is added to the sheltered period of development within the womb the suckling period in which the young still lives on the mother's capital—her milk. She supplies the milk from the savings left over after her bodily needs have been satisfied. And in man alone of all animals the period of dependence is prolonged beyond childhood—sometimes beyond manhood. Only the possession of capital makes this possible. It is in this sheltered period that preparations are made for adult life. Knowledge is absorbed—the accumulated store which has been amassed in the course of an infinite number of generations. We cannot collect and store the world's knowledge unless we have ample capital. Without capital we can neither preserve nor absorb knowledge.

I have touched my theme but lightly, but I hope I have treated it fully and clearly enough to show that progress in the evolution of living things and progress in the affairs of man are both equally dependent on the use of capital.